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United States Department of Agriculture,

DIVISION OF SOILS.

Cooperating with the Utah Experiment Station.

THE SOILS OF SALT LAKE VALLEY, UTAH.

OBJECT OF RECENT SURVEY.

In July, 1899, the Division of Soils, in cooperation with the Utah Agricultural Experiment Station, undertook a survey of that portion of Salt Lake County lying immediately west of the Jordan River and extending to the Great Salt Lake and the Oquirrh Mountains on the west, the object being to map the soils with particular reference to the extent of, and damage from, alkali and seepage waters.

EARLY IRRIGATION WORK.

Irrigation began here a half century ago and, for the most part, has been confined to that portion of the area nearest the river Jordan and south of the Twelfth street road. This irrigated portion consists of a number of benches, one above another, extending in a general direction parallel with the river and comprising an area about two miles wide and sixteen miles long, extending south from the Twelfth street road and bordering on the river—together with another portion not quite so wide, which turns westward—following the contour of the foothills and extending nearly to the point of the Oquirrh Mountains. The land slopes toward the river, or to the north, at the rate of fifty to one hundred feet per mile.

The earliest irrigation was successfully practiced on the Jordan meadows or bottom land, but later, when canals were constructed and irrigation began on the benches, the bottom land became so wet that the greater part of it has been abandoned and now lies as pasture or waste land.

RECENT IRRIGATION IMPROVEMENTS.

The latest, largest, and uppermost of the canals running over these bench lands is the Utah and Salt Lake, which is about two hundred feet above the level of most of the river bottoms and the low lands to the north. At its furthermost extremity this canal is about eleven miles west of the river. In the last six or seven miles of its course it passes over soil that is underlaid quite close to the surface by gravel, which is in turn underlaid at a considerable depth by an impervious layer of clay. The clay outcrops from one to two miles

north of the canal on considerably lower land. As a result of this structure and the considerable irrigation on the upper lands, a large area has here become so damaged by seepage water and alkali that it has been abandoned.

Both the South and North Jordan canals, which lie between the Utah and Salt Lake canal and the river, are responsible for much similar damage, especially at their outer extremities. Parallel with the Twelfth street road and about one mile south of it is a strip of land extending from the river about ten miles west, varying from one-half to one and one-half miles in width, all of which is more or less damaged by seepage water and alkali. Indeed, the damage has gone so far that a chain of lakes has been formed in this area, presenting a water surface of a thousand or more acres. This has all resulted from the seepage and surplus waters from the irrigated districts above. The total area which has been successfully irrigated is about fifty square miles, of which about ten square miles have been ruined by seepage water and alkali.

Of the larger, much lower, and level area, mostly north of the Twelfth street road and adjacent to Salt Lake City, extending from the river Jordan to Great Salt Lake and comprising about one hundred and twenty-five square miles, none has been successfully farmed, with the exception of a narrow belt along the river, although many attempts have been made and much money expended in this endeavor. About eleven years ago this area was the seat of an extensive boom—suburban townsites were laid out, streets graded, canals constructed, and artesian wells sunk; railroads were built and operated, parks were laid out and trees planted, buildings were erected for homes and stores, and, in the aggregate, hundreds of thousands of dollars were expended, for which no returns have ever been realized, excepting, perhaps, by the shrewd speculator.

The first-year crops that were cultivated gave fair returns; the second year failure was general, and the third year absolute. At present there are in this area many deserted houses and much unused land, which bears evidence of having once been cultivated. The cause of this failure and of the damage wrought by irrigation have, perhaps, never been fully understood by any one.

Four months were spent in a thorough and detailed examination of this area, and the large amount of data thus collected has given a far better understanding of the existing conditions than has ever before been realized. It is hoped that this knowledge will suggest the lines to be followed in order to overcome the difficulties that will be encountered in future attempts to farm this land.

The results of this work are embodied in the following statements, pending the completion of a detailed report:

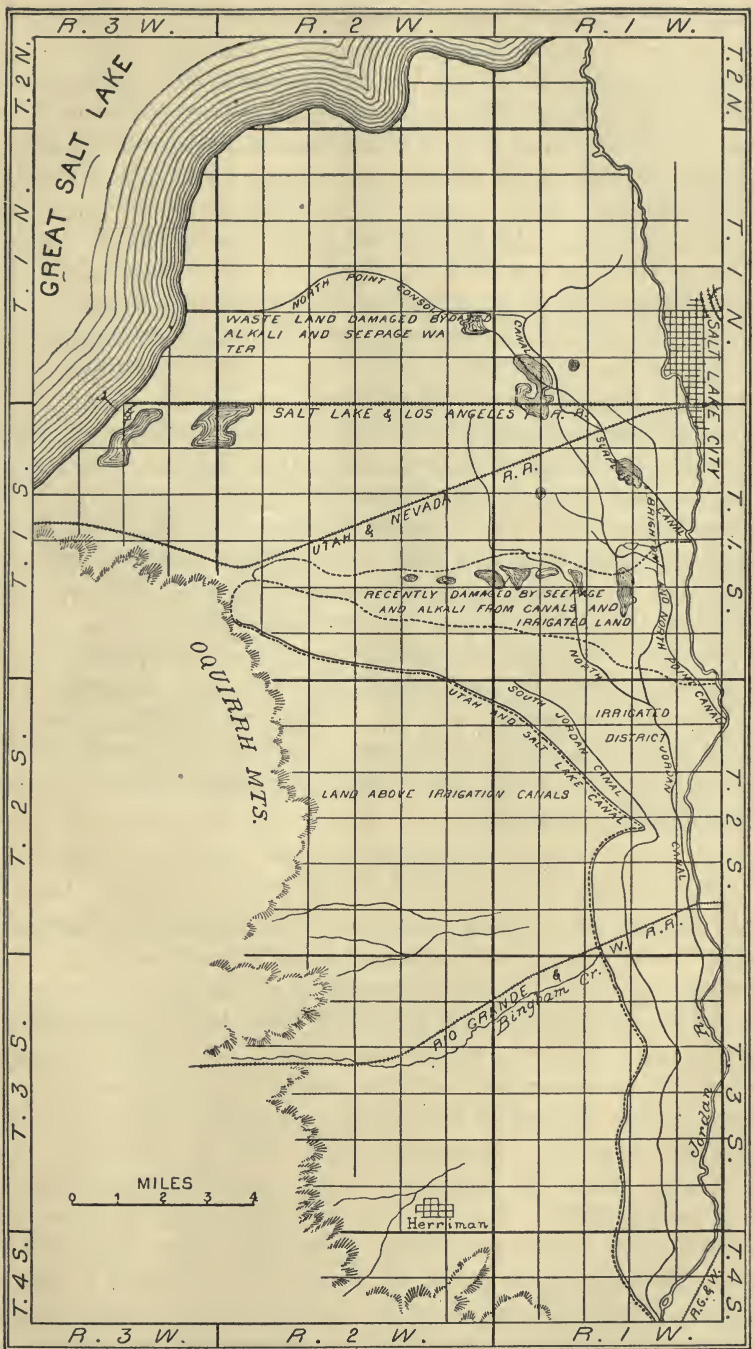

FIG. 1.—Map of a portion of Salt Lake Valley, Utah.

CLIMATE.

Rainfall records previous to the establishment of the Government weather service at Salt Lake City, show an annual variation of from 10 to 29.5 inches. At Salt Lake City the mean annual rainfall, according to the record of the past twenty-five years of the U. S. Weather Bureau, is 16 inches, with a minimum of 10.3 and maximum of 23.6 inches. Of this annual rainfall, less than three inches fall during the four warmest months of the year—June, July, August, and September. These four driest and warmest months, having a total mean rainfall of less than three inches and a mean temperature of 70.4° F., are accompanied by a low, relative humidity—conditions favoring excessive evaporation.

It is estimated that the annual evaporation from a free water surface in this locality is eight feet. Calculations from data of one of the salt companies show the evaporation from their ponds to be thirty-seven inches for the four months of June to September. It must be borne in mind, however, that this is from a saturated brine, and that the vapor tension, and consequently the evaporation, is much lessened by the presence of large quantities of salt.

Since the greater part of vegetable growth is made during these four months, these data show how important and necessary is irrigation for the production of crops. Indeed, no farming is carried on without irrigation except in the case of wheat, which makes most of its growth prior to June, and from which small yields is the rule rather than the exception.

WATER SUPPLY.

The Jordan River, from which all of the irrigation water used on the above area is taken, is the main channel through which the waters of a large number of streams extending well back into the mountains east and south, as well as the waters of Utah Lake and its inflowing streams, make their way to the Great Salt Lake. The annual precipitation in the mountains exceeds that in the valleys and is largely of snow, which lingers on the highest mountains during the greater part of the summer. The melting snow and the numerous mountain springs make the irrigation water supply constant, plentiful, and of good quality. The Utah and Salt Lake and the South Jordon canals get their water supply from the Jordan River, near the Jordan Narrows, and it is representative of the water of Utah Lake, which was found to contain eighty-nine parts of soluble matter in one hundred thousand parts of water. Of this only about fifty parts are likely to remain in solution and accumulate in the soil to the detriment of plants.

A few miles below the head of the South Jordan canal the seepage waters from the adjacent irrigated districts begin to return to the Jordan River. This seepage water, together with the unused portion of waters of the mountain streams to the east—Big and the Little Cotton Woods, Mill Creek, and City Creek, make the composition of the river water exceedingly variable during the remainder of its course. The seepage waters, with their high salt content, tend to make the water poor, while the mountain streams dilute and improve its quality.

The mean salt content of the North Jordan canal is about one hundred and seventy parts in one hundred thousand, or, practically, twice as much as that of the South Jordan. Below this the water of the Jordan, because of the entrance of mountain streams, improves; and we find the mean salt content of the Surplus and the North Point Consolidated canals to be about one hundred and thirty-five parts in one hundred thousand. About two hundred and fifty parts to one hundred thousand is the limit of safety.

In large irrigation canals water may flow for many miles and deteriorate very little in quality, while in small ditches the deterioration may become apparent through the evaporation of water and collection of salts from the banks of the ditch.

The aggregate capacity of the irrigation canals on this area is about six hundred cubic feet per second, but very much less than this amount of water is required or used on the twenty-five thousand acres that are now under irrigation. During the entire summer of 1899, large volumes of water were constantly passing the intake of the Surplus canal, and there is apparently enough water going to waste to irrigate all of the better lands west of Salt Lake City, between the river and the Lake.

SOILS.

The soils of this area have been classed under eight heads—

(1) Jordan sands.
(2) Jordan sandy loams.
(3) Jordan loams.
(4) Jordan clay and clay loams.
(5) Jordan meadows.
(6) Bingham gravelly loams.
(7) Bingham stony lands.
(8) Salt Lake sand (oolitic sand dunes).

1. The Jordan sands comprise a small area, usually a narrow belt along the bluffs bordering on the Jordan meadows or river bottom soils. The sand is generally fine-grained and continuous to six or more feet in depth, though occasionally underlaid at a less depth by loam or clay.

2. The Jordan sandy loam is the most important soil, both in point of area and of quality. It is a light sandy loam, ranging from one to several feet in depth and varying somewhat in its underlying strata. The most usual profile is two feet of sandy loam, one and one-half feet of loam and one foot of sand, all of which is underlaid by clay to a considerable depth.

3. The next most important type of soil is the Jordan loam, which is somewhat heavier than the sandy loam and, like the above, varies much in depth and underlying strata. Its most usual form is three feet of loam underlaid by clay, which frequently contains veins or pockets of fine sand.

4. An unimportant type of soil, agriculturally, at present is that of the clay and clay loams, which are low, level, wet areas lying near the lake (usually called "playas") and extending back into the better lands like fingers of a bay. It is all very salty and usually void of any vegetation. The clay is quite continuous to a considerable depth, although frequently inlaid with veins, or pockets, of very fine sand. The fingers, which extend far back like wide, irregular canals from four to eight feet deep, would furnish efficient drainage outlets for the adjacent good lands.

5. The Jordan meadows comprise a narrow belt, from a few rods to a half mile in width, which borders on the river Jordan. The soil being formed from the sediment of the river, is black and contains much organic material. It varies in depth from one to several feet, and in texture from sandy loam to clay. The most common form, however, is two feet of loam, two feet of clay, and one foot of coarse sand, all of which is underlaid by gravel. Where the gravel is not present, the soils are now usually very wet, and but little used except for pasture. The wetness is caused by seepage from canals and irrigated lands above. If drained, they would be fertile and productive.

6. Lying for the greater part above the irrigation canals is a large area of good land, which contains gravel within three feet or less of the surface. The gravel frequently comes to the surface, but it is here too small to materially interfere with cultivation. Below the surface the gravel becomes larger, and at several feet in depth may approach the size of bowlders. This area, considerable of which is dry-farmed to wheat, is called the Bingham gravelly loam.

7. The Bingham stony loam comprises a small and unimportant area near the foothills, which is too stony to be cultivated.

8. The Salt Lake sands (oolitic sands) are chiefly carbonate of lime, spherical in form and about the size of No. 10 shot. This sand is probably formed by the throwing down of carbonate of lime in the water of the lake, which is washed to the shore where the wind still

transports it further inland. It constitutes for the most part dunes along the lake shore and is of no importance agriculturally.

As is frequently the case with alluvial and sedimentary soils, the soils of Salt Lake Valley, especially those north of Twelfth street road, are heterogeneous and much mixed up, perhaps more so than is usual. They were probably first formed in the bed of the old lake, Bonneville, by sedimentation, and after its subsidence further modified by the vacillating shore of the more modern Great Salt Lake and the inflowing streams from the adjacent mountains.

ALKALI.

The salts, as they occur in the soil, vary greatly in quantity. In the best agricultural lands the amount present is frequently less than .05 of 1 per cent, while in the salt flats there may be as high as ten per cent, exclusive of the crust that frequently forms in much greater concentration. Sodium chloride, or the common salt of commerce, forms from fifty to ninety-seven per cent of the total salts present. Besides this, there are considerable quantities of the sulphates of soda, lime, and magnesia, chlorides of lime and magnesia, and also carbonate of soda, or true black alkali. The black alkali is nearly always present in amounts varying from a trace up to several per cent in small local spots. There is, in the aggregate, a large area in which it occurs in sufficient quantity (.1 per cent) to be fatal to crops.

It seems quite probable that this accumulation of salt came chiefly from two sources—i. e., from the higher lands to the south and from the waters of Great Salt Lake. It is most likely that the lake is the source of the greater portion of them, for when it was from thirty to fifty feet higher than now, it would have submerged nearly all the area under consideration, and must have also contained much salt in solution. Upon the subsidence of the water the soil would, of course, be left heavily impregnated with salts. Besides, within the memory of the present inhabitants, the lake has again submerged a considerable part of this area, and, according to reliable records, the lake in 1868 was twelve feet above its present level, and at this height must have covered at least fifty square miles of what is now mapped as dry land. The water at that time carried, approximately, 13.5 per cent of salt, and land submerged for a considerable length of time in such a solution would certainly be left very salty when the water subsided. More land than that merely covered by the lake must have been affected by it. The water-table of the low land adjacent to the shore must have risen to an elevation equal to or exceeding the level of the lake water, while in time of storms the waves may have rolled inland for considerable distances. It is fair to assume that all land now having an elevation not to exceed twenty feet

above the present lake level, was more or less affected by its waters at that time.

Practically all of the comparatively level area north of Twelfth street road, when considered to a depth of five feet, is salty land. There are considerable portions of it, however, in which the salt content of the first, and sometimes the second, foot is so small as to indicate that it could be safely used for agricultural crops. Below the second foot the salt increases very rapidly and far exceeds the limit for most plants. This increase continues as we descend until within one foot of the water-table, where the maximum is reached. Below the water-table the saltiness is quite constant for a number of feet, diminishing slightly as we descend. On this type of land, usually sandy loam or loam, the water-table is seldom more than six or seven feet below the surface, though it is occasionally as much as ten feet. It is on this land that numerous, unsuccessful attempts have been made at farming during recent years, and the failure has undoubtedly been due to the following causes:

In its natural state this land is, for the most part, covered with a growth of greasewood. The salts having been carried from the surface into the deeper soil by the natural precipitation, were undoubtedly largely prevented from rising again by this deep-rooted plant absorbing the soil moisture at its roots, thus preventing much surface evaporation. When this land was broken up for cultivation, the soil moisture instead of being thus absorbed in the lower soil, rose into the upper, bringing the salts with it, to the detriment of the shallow-rooted agricultural plants. The land, being level and underlaid with a strata having a fairly close texture, had naturally poor drainage. The water-table was rarely more than seven feet below the surface and frequently of less depth, and upon the application of irrigation water it gradually rose. When the water-table was within three feet of the surface much evaporation naturally occurred from the resulting moist soil surface. In this condition the salts from the lower soil rapidly rose to the surface and were left by evaporation as incrustations, or were moved up and down in the surface soil with the movement of the rain and irrigation water, in such concentration as to prevent the growth of most plants.

Under these conditions farming was a failure, and at present few attempts are being made to do anything with this kind of land. There are a few places of limited extent along the border of draws, or on ridges, where the natural drainage is sufficiently good for irrigation farming to be carried on. With good judgment as to irrigation and cultivation, some of these places are producing alfalfa and garden products successfully. These places, while insignificant in

themselves, are very suggestive as to the means by which all of this area might be reclaimed.

As an illustration of the effect that elevating the water-table has upon the accumulation of salt in the surface soil, take, for example, the playas and all low ground where the water-table is within three feet or less of the surface and we find that the surface portion of the soil is almost invariably the most salty, and is very often covered by a salt crust.

The irrigated land south of the Twelfth street road has, for the most part, good, natural drainage, and is generally quite free from salts. There are a few areas, however, including the greater part of the Jordan meadows, which form an exception. Here, owing to poor, natural drainage, seepage water has accumulated from the irrigation of lands above, and the injury is more from water than from salt. In most cases, however, the seepage water is accompanied by an accumulation of salts immediately at or near the surface. The source of these salts is usually from the seepage water accompanied, perhaps, by an upward movement of the original salts of the soil. This accumulation at the surface is brought about by the excessive evaporation from the wet surface of the soil.

THE PROBLEMS OF THE AREA.

The areas damaged by seepage and alkali would be less extensive if there had been a more judicious management of the irrigation water. Because of an abundance of water, it has at times been used in excessive amounts. and, furthermore, waste or surplus water is too often allowed to run on to vacant lands when the canal gates should be closed. Each irrigation should be of sufficient quantity to wet the ground to a considerable depth and yet cause little or no drainage. The soil moisture should be conserved by the best means of cultivation and cropping, thus making the intervals between irrigations as long as possible. It is true that lands are sometimes of such a character that large areas cannot be irrigated without causing seepage water to escape. Where damage is already done, the land can sometimes be redeemed by warding off the seepage by means of a drain along the upper side of the affected area. It will, however, usually require a system of drains to affect this, and, if salts have accumulated to a considerable extent, thorough drainage is the only recourse.

DRAINAGE.

Of the one hundred and twenty-five square miles lying mostly north of Twelfth street road and between Salt Lake City and the lake, ninety square miles, or about fifty-eight thousand acres, are

capable of reclamation. For this portion, tile drainage is recommended as of general application. There is a constant and plentiful water supply of good quality for irrigation, which may be obtained without the construction of costly dams and storage reservoirs so frequently required in many of the irrigated districts.

The soil is of good texture and the land lies so as to be easily irrigated. Furthermore, its proximity to the metropolis of the State makes it more valuable than if it were far removed from a commercial center. The excess of salts is the principal obstacle in the way of this area being profitably farmed. The problem, therefore, resolves itself into how to get rid of the salts. There is no antidote for them, except in the case of sodium carbonate or black alkali. For this, gypsum is a corrective. Unfortunately, where there is an excess of sodium carbonate there is also an excess of the other salts, and to convert the black alkali into white alkali by the use of gypsum would still leave an excess of salts in the soil. There is only one feasible way of getting rid of these salts, and that is by providing a thorough system of under drainage and washing them out by flooding.

Surface washing without drainage is of little avail, for the first application of water dissolves the salts and they pass into the ground only to return to the surface when evaporation commences. If tile drains are present the dissolved salts will pass through them and thus be carried away, so that further damage from them need not be feared. The question that must be answered is, Will it pay to reclaim these lands? This will be determined by the present value of the land, the cost of reclaiming, and the value of the land after being reclaimed.

An estimated value for the land of fifteen dollars per acre, while much less than some of it is being held for, is more than its real value, which, in its present condition, is merely nominal. Good farming land on the east side of the Jordan River, having a water right and free from alkali, can easily be sold at from seventy-five to one hundred dollars per acre. There is no reason why the alkali land west of the river should not be pretty nearly as valuable when reclaimed and a good water right secured.

The cost of drainage will vary somewhat, according to the character of the soil and the price of labor and material. The Jordan sandy loams and Jordan loams will be most easily reclaimed because of their lighter texture. The distance between drains will be determined by the texture of the soil. The more open the texture and structure of the soil, the more readily will water pass through it and the greater can be the distance between drains. The depth should be three feet or more. The rate of removing the salts will depend principally upon the rate of movement of the soil waters.

For drains three feet deep and at a uniform distance of one hundred feet apart, the cost should not exceed fifteen dollars per acre. While the proper distance between drains can be accurately ascertained only by experiment, yet it is our judgment that a distance of one hundred feet between drains could frequently be increased and would seldom require to be decreased. In addition to the above, there would be the cost of constructing outlets to conduct the water to the lake or river. For this area, the expense would be comparatively small, on account of the long draws that now extend back into the land like irrigation canals. These may require deepening and supplementing in places.

In order to be carried out in the most economical way, drainage should be made a community affair, and the systems should be planned with reference to a general scheme, especially where a large number of land owners are involved.

FRANK D. GARDNER,
Assistant, Division of Soils.

JOHN STEWART,
Assistant Chemist,
Utah Experiment Station.

The publication of this circular, approved by Prof. Milton Whitney, Chief of the Division of Soils, and Prof. Luther Foster, Director of the Utah Experiment Station, is hereby authorized.

JAMES WILSON, *Secretary.*

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